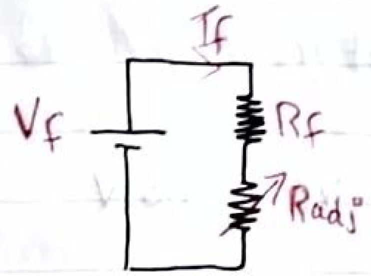
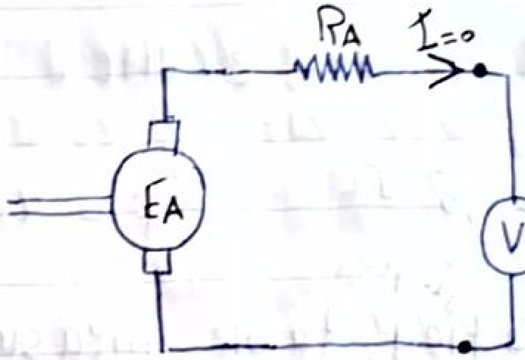
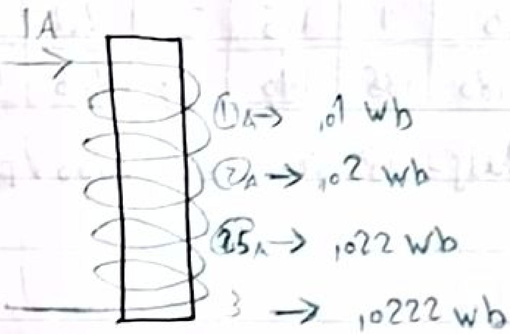
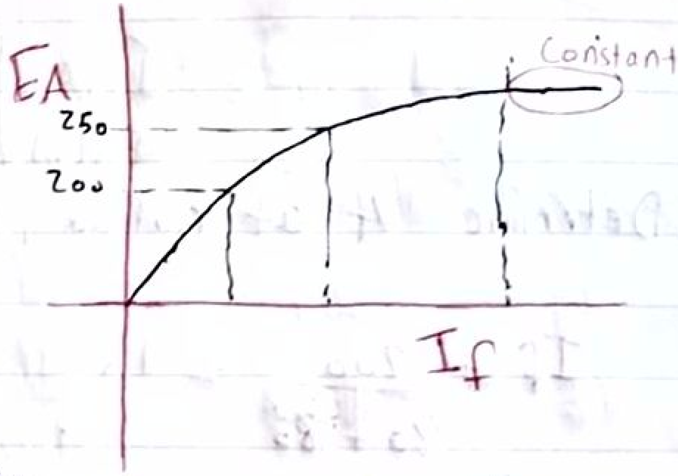




$$E_A = K \phi \omega$$





Ex: $E_{A1} = 100\,V$, $I_f = 1A$, $n = 1000\ rpm$
$E_{A2} = ??$, $I_f = 1A$, $n = 1500\ rpm$

اقسم اعلى

$$E_{A1} = \cancel{K} * \cancel{\phi} * n_1 * \cancel{\frac{2\pi}{60}} = 100$$

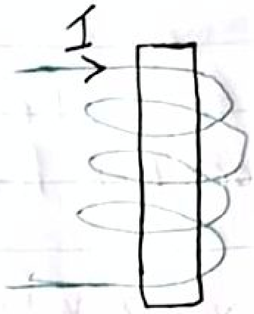
$$E_{A2} = \cancel{K} * \cancel{\phi} * n_2 * \cancel{\frac{2\pi}{60}} = ??$$

$$\frac{100}{E_{A2}} = \frac{n_1}{n_2} \Longrightarrow E_{A2} = \frac{100 \times 1500}{1000} = 150\ V$$

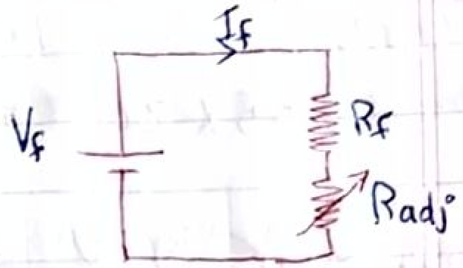
E_A , R_{adj} , n يكون معطينا إثنين منهم ونطلع الثالث

Shunt $\xrightarrow{\text{معناها}}$ Prallel

* fulx → { Permament magnet → un Contorlled ; elector magnet → contorlled }



* field circuit :



$$\phi = \frac{MMf}{R} = \frac{NI}{R}$$

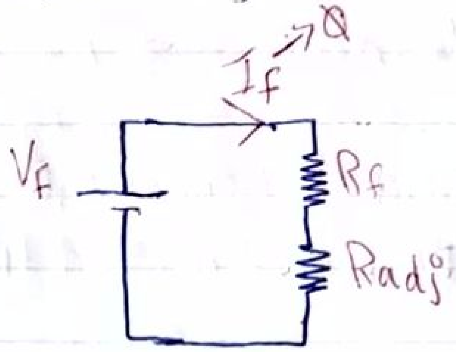
$$I_f = \frac{V_f}{R_F + R_{adj}}$$

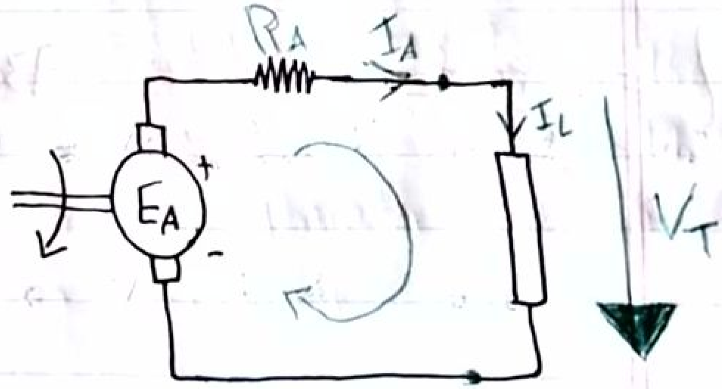
التحكم بـ Q

إذا كانت صغير
يكون الـ $I_{f\,Max}$

* DC - genertors types

1) separtely excied

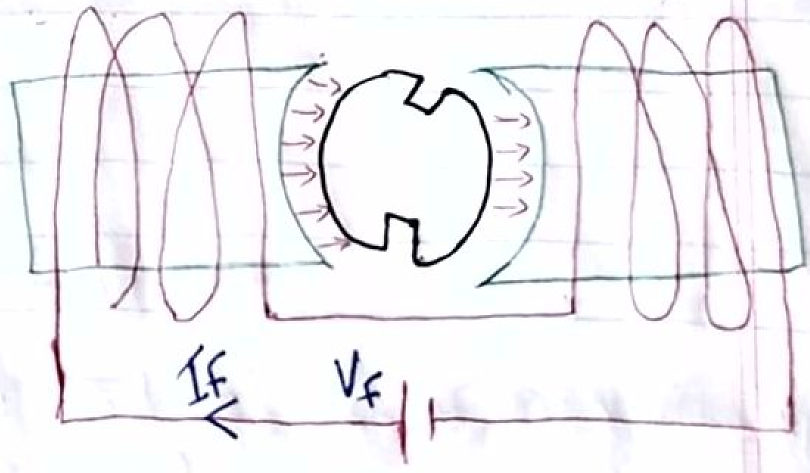




$$I_f = \frac{V_f}{R_F + R_{adj}}$$

$$E_A = V_T + I_A R_A$$

$$I_L = I_A$$



4) Detrmine applied torque (Input) for Case(2) if friction losses = 100 watt

$P_{input} = P_{developed} + P_{frication}$

$= 155 \times 20 + 100 = 3200$ watt

$P_{input} = K \phi W = \frac{640 \times 4}{2\pi \times 4} * .02 * W = 155$

$W = 76$ rad/s

$T_{inp} = \frac{3200}{76} =$

$\eta = \frac{P_{out}}{P_{inp}} = \frac{150 \times 20}{3200} = 93.7\%$

$$T_{app} = \frac{P_{friction\ losses} + P_{developed}}{W}$$

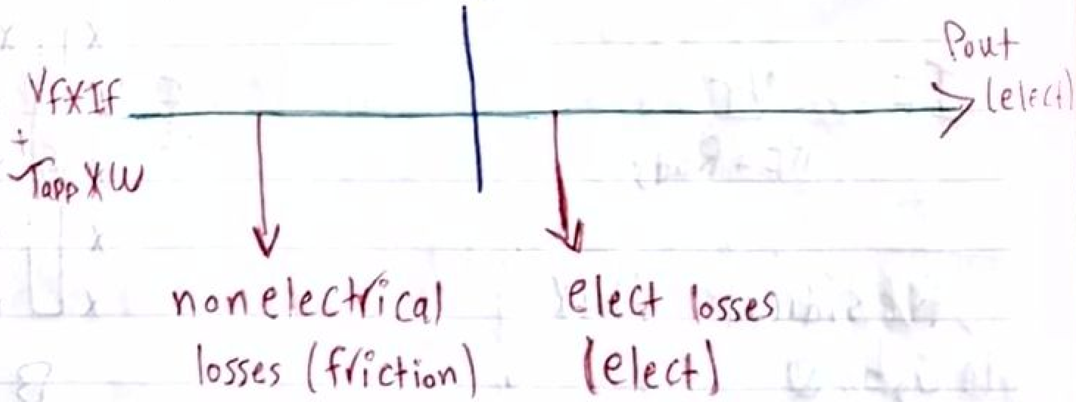
* Sep excited DC generator $\eta = 80\%$, $P_{out} = 10kW$
$V_f = 200\ V$, $I_f = 10\ A$, $n = 1000\ rpm$

Detrmine applied torque

$$.8 = \frac{10000}{T \times 1000 \times \frac{2\pi}{60} + 200 \times 10} \Longrightarrow T = 100\ N.m$$

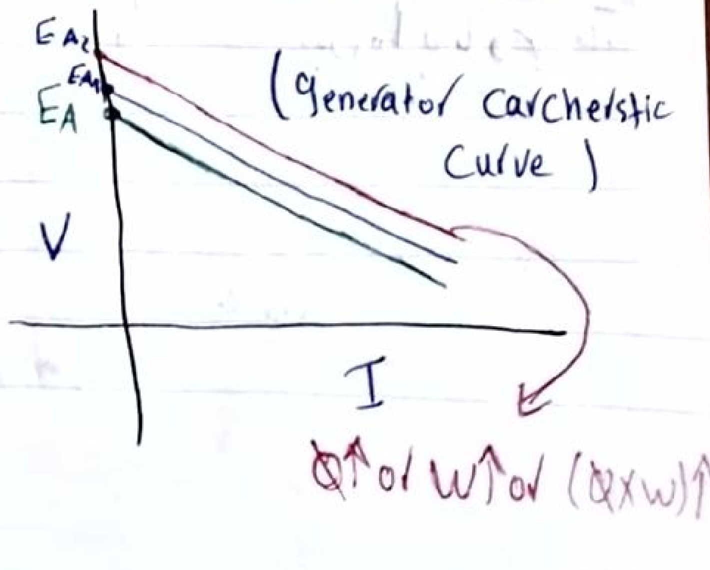
* power flow diagram :

$P_{deve} = E_A \times I_A$



Pout (electrical) $V * I$

$V_T = E_A - I_A R_A$



2) Determine Radj required for the generator to supply output of 20 KW, $V_T = 500$ V, speed = 1000 rpm

$$I_L = \frac{20000}{500} = 40 \text{ A}$$

$$E_A = 500 + 40 \times 0{,}12 = 504{,}8 \text{ V}$$

504,8 ⟶ 1000 rpm

E ⟶ 800 rpm

كل ما زادت السرعة يتزيد E_A

4,8	390
If	403,8
6,4	460

$$\frac{4{,}8 - I_f}{4{,}8 - 6{,}4} = \frac{390 - 403{,}8}{390 - 460}$$

$$I_f = 5{,}11 \text{ A}$$

$$I_f = \frac{V_f}{R_f + R_{adj}} \Rightarrow 5{,}11 = \frac{200}{25 + R_{adj}} \Rightarrow R_{adj} = 14{,}14\ \Omega$$

* $P_{inp}(\text{total}) = P_{inp}(\text{mech}) + P_{inp}(\text{elect})$

$$\eta = \frac{P_{out}}{P_{inp\ total}}$$

$P_{inp}(\text{mech}) = P_{friction\ losses} + P_{developed}$

* DC - sep excited generator

Ex: DC - sep excited generator, $V_f = 200\ V$
Armature Resistance $R_A = 0.12\ \Omega$, field Resistance $= 25\ \Omega$

800 rpm

If	1,6	3,2	4,8	6,4	8,1	9,6	11,2	11,8	A
EA	148	285	390	460	520	560	590	605	V

1) if the prime mover speed = 1200 rpm, Radj = 6 Ω
$R_{load} = 10\ \Omega$, determine termined Voltage (V_T) and output Power

$$I_f = \frac{200}{25+6} = 6.45\ A$$

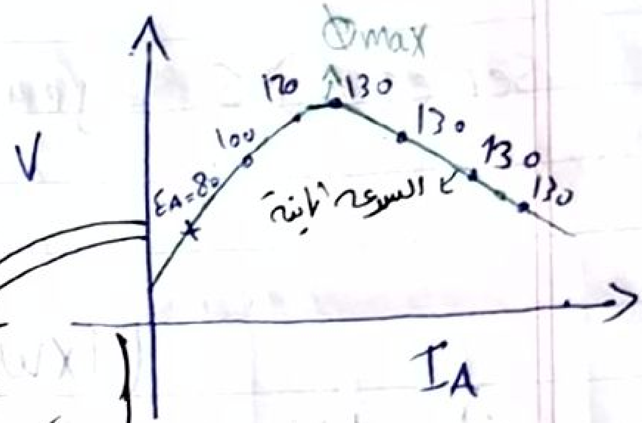
كل الجدول لبروح كل تقريبي 6,4

$$460 \longrightarrow 800\ rpm$$
$$E_A \longrightarrow 1200$$
$$\Longrightarrow E_A = \frac{1200 \times 460}{800} = 690\ V$$

$$I_A = I_L = \frac{E_A}{R_A + R_{load}} = \frac{690}{0.12+10} = 68.18\ A$$

$$P_{output} = (I_L)^2 \times R_{load} = (68.18)^2 (10) = 46.485\ Kwatt$$

$$\tau_{ind} = \frac{E_A \times I_A}{\omega} = \frac{P_{out} + I_A^2 R_A}{\omega} = \frac{690 \times 68.18}{1200 \times \frac{2\pi}{60}} = 749\ N.m$$



(Charcterstic curve of DC series generator)

Ex: DC_serPes generator $\eta = 90\%$, $P_{inp} = 10$ hp
$V_T = 200$ volt, $n = 1000$ rpm

Detrmine develoPed Power, τ_{ind}, $\tau_{applied}$

$P_{inp} = 746 \times 10$ watt

$P_{out} = .9 \times 746 \times 10$

$V_T = 200$

$$I_L = \frac{.9 \times 746 \times 10}{200} = I_f = I_A$$

$E_A = 200 + I_A |.6| \Rightarrow$

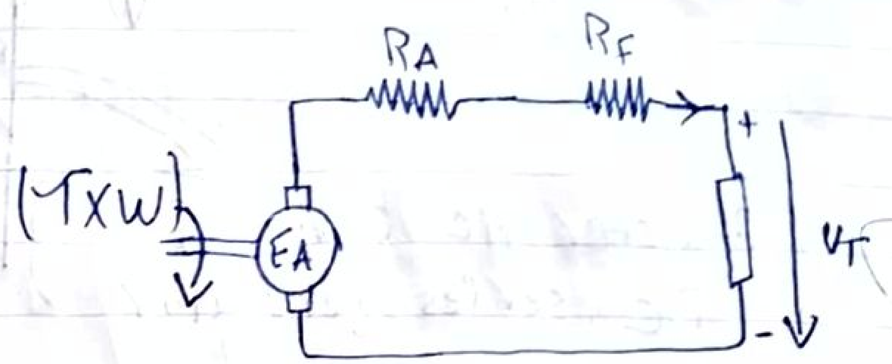
1) $P_{dev} = E_A * I_A$

2) $$\tau_{ind} = \frac{E_A * I_A}{\omega} = \frac{E_A \times I_A}{1000 \times \frac{2\pi}{60}}$$

3) $$\tau_{app} = \frac{10 \times 746}{1000 \times \frac{2\pi}{6}}$$

4) friction losses
$P_{inp} - P_{dev}$

2) series DC generator



$V_T = E_A - I_A R_A$ $\qquad$ $I_A = I_L = I_f$

$I_L\uparrow = I_A\uparrow = I_f\uparrow$ $\to$ $\phi\uparrow \Rightarrow E_A\uparrow \Rightarrow V_T\uparrow$

$\qquad\qquad\qquad\qquad$ $\to$ $-I_A(R_A + R_f)\uparrow \Longrightarrow V_T\downarrow$

E_A	I_A	V_T	
110V	10 A	100 V	$(R_A + R_s) = 1\Omega$
150V	15 A	$150 - 15 \times 1 = 135$ V	

50 turns

10 turns

E_A	I_A	V_T
100V	10A	90 V
105	15A	$105 - 15 \times 1 = 90$V
108	20	$108 - 20 \times 1 = 88$ V

✱ DC - shunt generator with $\eta = 80\%$

$P_{inp(mech)} = 5\,KW$, $V_T = 100\,V$, $R_f + R_{adj} = 100\,\Omega$

$R_A = ,5\,\Omega$, speed $= 1400\,rpm$

1) Detrmine developed power

$$P_{out} = 5000 \times ,8 = 4000\ \text{watt}$$

$$I_L = \frac{4000}{100} = 40\,A$$

$$I_f = \frac{V_T}{R + R_{adj}} = \frac{100}{100} = 1\,A$$

$$I_A = I_L + I_f = 40 + 1$$

$$P_{deve} = E_A * I_A$$

$$E_A = 100 + 41 \times ,5 = 120,5\,V$$

$$P_{deve} = 120,5 \times 41 = 4940,5$$

$$T_{ind} = \frac{P_{dev}}{w} = \frac{4940,5}{1400 \times \frac{2\pi}{60}} = 33,7\ N.m$$

$$T_{app} = \frac{5000}{1400 \times \frac{2\pi}{60}} = 34,1\ N.m$$

$V_T \Rightarrow 220 - 505(,03 + ,004) \Rightarrow 202$ Volt

$204 \rightarrow V_T$ at no load

$\therefore$ under Compound

* $N_s = ??$ flat

$I_f = 5A$, $n = 950$ rpm , $I_L = 500$ A

$V_T = E_A = 204$ $\qquad I_f = I_f^*$

$204 = E_A - 505(,03 + ,004)$

$E_A = 221,1 \longrightarrow 950$ rpm $\Longrightarrow I_f^* = 9.3$

$?? \longrightarrow 1000$ rpm $\Longrightarrow I_f^* = 9.3$

بنرجع على الجدول 232,7

flat $\rightarrow V_{n,L} = V_{f,L}$

$I_f^* = 9,3A$

$9,3 = 5 + \frac{505 \times N_s}{1200} \Longrightarrow N_s = 10,2$ turns

$\phi_{net} \Rightarrow I_f^*$

$\phi_{sh} \Rightarrow I_f$

$$\boxed{I_f^* = I_f \pm I_A * \left(\frac{N_s}{N_f}\right)} \quad / * N_f$$

series field turns (N_s)

shunt field turns (N_f)

$$N_f * I_f^* = N_f I_f \pm I_A * N_s$$

EX: DC - generator, long shunt, Cummulative Compound, $R_A = .03\ \Omega$, $R_S = .004\ \Omega$, $N_f = 1200$ turns, $N_s = 5$

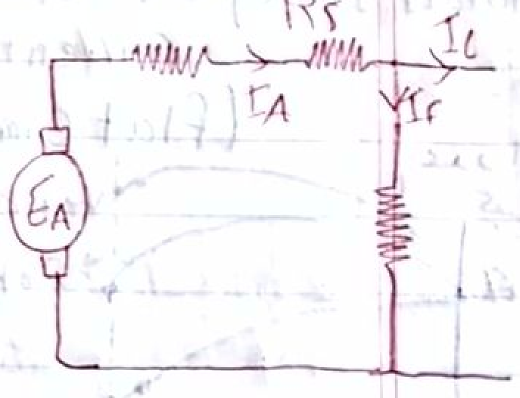
I_f^*	0	1	2.2	2.9	3.3	5.1	7.1	[redacted]	9.2
EA	11	33	100	140	167	215	222	[redacted]	232

1) Determine termnal Voltage (V_T), $I_L = 500$ A

$I_f = 5A$, $n = 950$ rpm

$(I_L + I_f) = I_A$

$$I_f^* = 5 + 505 * \frac{5}{1200} = 7.1\,A$$



222 V $\rightarrow$ 1000 rpm

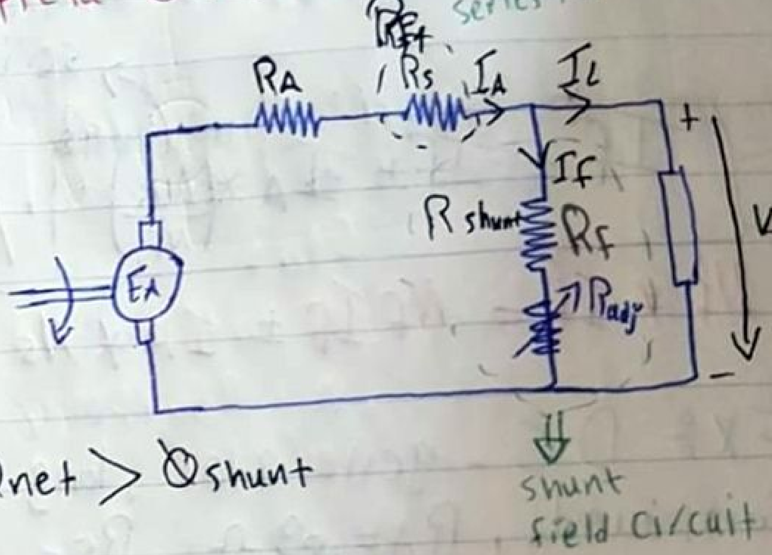
EA $\rightarrow$ 950 $\Rightarrow$ EA = 211

$$V_T = E_A - I_A(R_A + R_S) = 211 - 505(.03 + .004) = 193.8\ V$$

[redacted]

* Compound DC generator

(shunt + series) field circuit



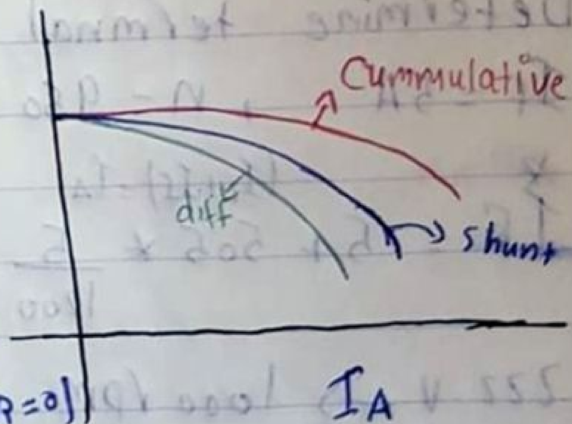
$$E_A = K\phi_{net}\omega$$

$$\boxed{\phi_{net} = \phi_{f\,(shunt)} + \phi_s}$$

(Cummulative) $\Longrightarrow$ $\phi_{net} > \phi_{shunt}$

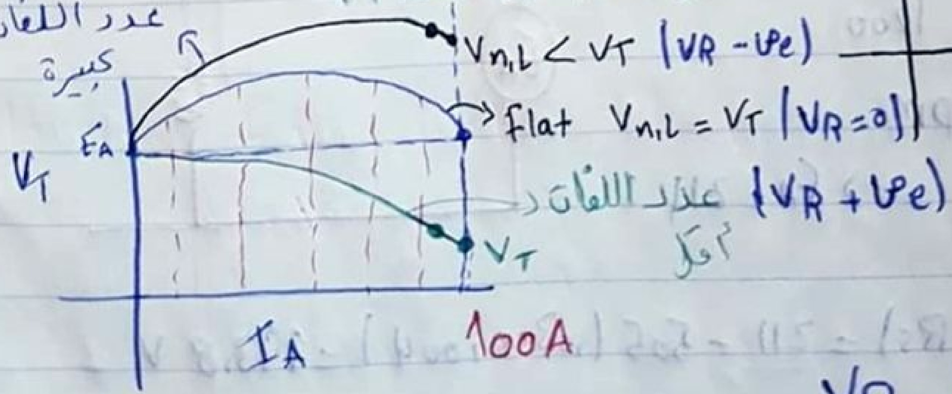
$$\boxed{\phi_{net} = \phi_{f\,(shunt)} - \phi_s} \Longrightarrow \text{Differential}$$

$\phi_{net} < \phi_{shunt}$



$V_{noload}(I_A=0) = V_T$ at rated current

(flat Compound)



$$VR = \frac{E_A - V_T}{V_T} * 100\%$$

$$I_f^* = 2{,}5 - \frac{100}{800} = 2{,}3\,A$$

$$\begin{aligned} 87 &\leftarrow 1800 \\ E_A &\leftarrow 2000 \end{aligned} \Longrightarrow E_A = 96{,}6\,V$$

$$V_T = 96{,}6 - 20 * {,}25 \Longrightarrow 91{,}6$$

V_T (no load) $n = 2000$ rpm

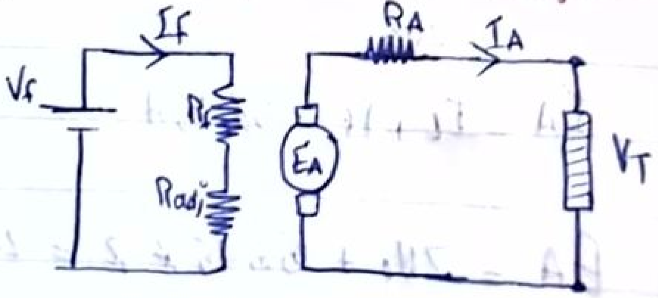
$$I_f = \frac{100}{20+20} = 2{,}5$$

$$I_f^* = I_f - 0 = 2{,}5$$

$$\begin{aligned} 91 &\leftarrow 1800 \\ E_A &\leftarrow 2000 \end{aligned} \Longrightarrow E_A = 101{,}1\,V = V_T$$

$$VR = \frac{101{,}1 - 91{,}6}{91{,}6} * 100\% = 10\%$$

3) If the generator has an armature reaction AR=100 A.turns
$I_{load} = 40\,A$, $n = 2000$ rpm, $V_T = 100\,V$, Determine R_{adj}



$$E_A = 100 + 40 \times {,}25 = 110\,V$$

$$\begin{aligned} 110 &\longrightarrow 2000\,rpm \\ E &\longrightarrow 1800 \end{aligned} \Longrightarrow E_A = 99\,V$$

* EX: Sep excited DC generator with magnetization table as follow

$R_A = 2\,\Omega$, $R_f = 20\,\Omega$, $N_f = 800$ turns, $V_f = 100$ V

1800 rpm

I_f^*	1	2	2,3	2,5	2,7	2,9	3	4	A
E_A	40	80	87	91	96	97	99	120	V

1) Determine V_T at no load condition, $n = 1700$ rpm

$R_{adj} = 20\,\Omega$

في حالة ال no load

$V_T = E_A$ at no load

ال If هي نفسها I_f^*

$$I_f = \frac{100}{20 + 20} = 2.5\ A$$

91 ⟶ 1800 rpm

?? ⟶ 1700

$E_A = 85.9$

2) Determine voltage regulation if output current = 20 A

AR = 100 A.turns, speed = 2000 rpm, $R_{adj} = 20\,\Omega$

* full load (20) A

AR at no load = 0

$$I_f = \frac{100}{20 + 20} = 2.5\ A$$

* Armature reaction : يقلل الفلكس في الـ generator

if Armature reaction is not compensated is not neglected

$$I_f^* = I_f - \frac{AR}{N_f}$$

sep excited	Shunt	Series
$I_f = \frac{V_f}{R_f + R_{adj}}$	$I_f = \frac{V_T}{R_F + R_{adj}}$	$I_f = I_A = I_L$
$I_f^* = I_f - \frac{AR}{N_f}$	$I_f^* = I_f - \frac{AR}{N_F}$	$I_f^* = I_f - \frac{AR}{N_f}$

Compound

$$I_f^* = I_f \pm I_A \frac{N_s}{N_f} - \frac{AR}{N_f}$$

#KoJoK

Dc _ Machine

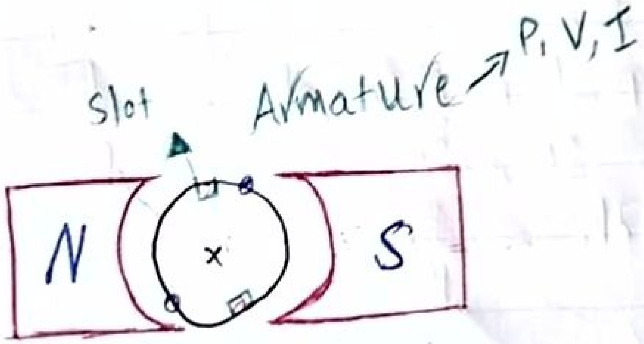
- Dc generators
- Dc Motors

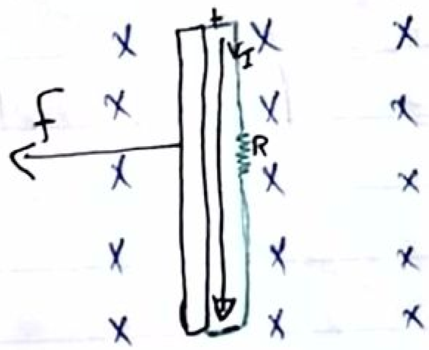
$P_m = T \times \omega\ [W]$ (الوحدة) $P_G = V \times I = I^2R = \frac{V^2}{R}$

* كيف يتم الحصول على الحركة

1) fuel 2) Wator (hydro) 3) Steam 4) wind (Prime mover)

Genrator action





Single layer

# of Condnctor $Z = 2CN$ → # of turns

# of coil

$218 \longrightarrow 1700$

$251{,}39 \longrightarrow n \implies n = 1960{,}38$ rpm

* With AR $\implies$ 2000 A.turns

$I_f^* = 1 - \frac{200}{1000} = .8$ A

$215 \longrightarrow 1700$ rpm

$251{,}38 \longrightarrow n \implies n = 1987{,}7$ rpm

b) Determine rotational losses, applied torque induced torque for Cas(a)

Without AR:

Rotation losses = Pinp − Pout − elect losses

$= P_{inp} - P_{dev}$

$= 20 \times 746 - (251{,}39 \times 56{,}95) = 603{,}4$ watt

$T_{app} = \frac{P_{inp}}{\omega} = \frac{20 \times 746}{1960{,}38 \times \frac{2\pi}{60}} = 72{,}7$ N.m

$T_{ind} = \frac{E_A \times I_A}{\omega} = \frac{251{,}39 \times 56{,}95}{1960{,}38 \times \frac{2\pi}{60}} = 69{,}7$ N.m

$218 \rightarrow 1700$
$251,39 \rightarrow n \Longrightarrow n = 1960,38$ rpm

* With AR ⟹ 200 A.turns

$I_f^* = 1 - \frac{200}{1000} = ,8$ A

$215 \rightarrow 1700$ rpm
$251,38 \rightarrow n \Longrightarrow n = 1987,7$ rpm

b) Determine rotational losses, applied torque induced torque for Cas(a)

Without AR:

Rotation losses = Pinp − Pout − elect losses
$= P_{inp} - P_{dev}$
$= 20 \times 746 - (251,39 \times 56,95) = 603,4$ watt

$T_{app} = \frac{P_{inp}}{\omega} = \frac{20 \times 746}{1960,38 \times \frac{2\pi}{60}} = 72,7$ N.m

$T_{ind} = \frac{E_A \times I_A}{\omega} = \frac{251,39 \times 56,95}{1960,38 \times \frac{2\pi}{60}} = 69,7$ N.m

Ex: DC - sep excited generator

$R_A = .5\ \Omega$, $R_f = 20\ \Omega$, $V_f = 200\ V$

Magnetization table measured at constant speed = 1500 rpm

$I_f(A)$	.5	1	1.5	2	2.2	2.5	3
$E_A(V)$	180	185	190	200	205	210	212

1) Detrmine V_T at noload , $R_{adj} = 180\ \Omega$, $n = 2000$ rpm

$$I_f = \frac{200}{20+180} = 1A$$

185 V $\longrightarrow$ 1500 rpm
E_A $\longrightarrow$ 2000 rpm $\Longrightarrow E_A = \frac{2000 \times 185}{1500} = 246.6\ V$

2) Detrmine Required for the genrator to deliver out put 10 KW , $V_T = 200\ V$, $R_{adj} = 80\ \Omega$

$$I_f = \frac{200}{20+80} = 2A$$

$$I_L = \frac{10 \times 10^3}{200} = 50\ A \Longrightarrow I_A = I_L$$

$$E_A = V_T + I_A R_A = 200 + 50 * .5 = 225\ V$$

200 $\longrightarrow$ 1500
225 $\longrightarrow$ n $\Longrightarrow n = \frac{225 \times 1500}{200} = 1687.5$ rpm